# Group Problem 5 

March 8, 2012

1. Consider a small block of mass $m$ sliding down the frictionless surface of a sphere, held completely at rest (no translation or rotation allowed). The radius of the sphere is $R$. If the mass is released with neglible speed from the top (North Pole) of the sphere, what is the vertical distance from the top at which the mass loses contact with the sphere?
2. Some material consisting of a collection of microscopic objects is kept at a high temperature. A photon detector capable of detecting photon energies from IR through UV observes photons emitted with energies of $0.3 \mathrm{eV}, 0.5$ $\mathrm{eV}, 0.8 \mathrm{eV}, 2.0 \mathrm{eV}, 2.5 \mathrm{eV}$ and 2.8 eV .These are the only photon energies observed.
(a)Assuming that none of the possible quantum transitions between different energy levels are forbidden, how many different energy levels does the microscopic system have?
(b)Draw and label all possible energy-level diagrams for one of the microscopic objects. You can take the ground state to have energy $E_{0}$.
(c)Would a spring-mass model be a good model for these microscopic systems? Why or why not?
(d)The material is now cooled down to a very low temperature, and the photon detector stops detecting photon emissions. Next a beam of light with a continuous range of energies from IR through UV shines on the material, and the photon detector observes the beam after it passes through the material. What photon energies in this beam of light are observed to be significantly reduced in intensity("dark absorption lines")according to the energy diagrams
you found in part (b)? If you observe a 2.5 eV dark line in the absorption spectrum, can you infer which one of the energy diagrams in part(b) is correct?
